INTRODUCTION (2 min)

CIVIL AIR PATROL
INTRO TO SPACE
STK LESSON PLAN FOUR:
CONDUCTING SATELLITE OPERATIONS

PP Slide 1

ATTENTION:

Now that you have your satellites in orbit, what are you going to do with them?? We will next look at conducting satellite operations, and the different ground and air segments that link everything together.

MOTIVATION:

It is vital to know the background on space systems operational concepts in order to understand how to best use satellites in orbit. We will now focus on space system elements, illustrate how operations are conducted by using a real world example, GPS, and describe how space system elements work together.

OVERVIEW:

1. Define the basic elements of a space system.
2. Explain how a space system functions.
3. Understand how access plays into the design of the space system.

TRANSITION: Let's now look at the different parts of a space system

BODY (1 hour)	
PRESENTATION.	
A. PART I – OVERVIEW 1) Let us now look at the elements that make up a space system, and how the all fit together to conduct satellite operations. We will also cover space system functions and access, as part of this lesson.	**PP SLIDE 2**
a) **Space System Elements** Space operations center on the transfer of data between a satellite and a user. A space system, comprised of three elements, is needed to support this transfer of data. A space system consists of a ground segment, space segment, and data link segment. Each segment has a very important role in conducting operations. Consequently, a failure in any segment can prevent satellite operations from being conducted. Let us look at each segment separately.	**PP SLIDE 3**
b) **Ground Segment** The ground segment conducts command and control, and telemetry operations. **Command and control** operations are the actions required to send instructions to the satellite. These instructions include turning equipment on and off, moving the satellite orbit and telling the satellite where and how to perform its mission. **Telemetry** operations are the collection of raw data received from the satellite. 1) Telemetry data is divided into two areas. a) First, there is the telemetry data describing the satellite's functional status. It is referred to as the satellite's "health and status" data. b) Second, there is the mission equipment telemetry data providing information on the satellite's mission.	
2) In order to conduct operations, the ground segment needs four components: ground antennas, a command and control center, a mission payload center, and personnel.	

a) **Ground antennas** collect information from the satellite and forward the raw data to the command and control center and/or mission payload processing center. Ground antennas also send the satellite control commands to the satellite.	
b) The **command and control center** is the "brains" of the space system. Large computers inside the center generate commands (instructions) to be transmitted to the satellite via the ground antennas. Also within the command and control center, satellite telemetry is monitored by personnel to ensure the satellite remains functional and in its proper obit	
c) The **mission payload center** controls how specific sensors or communications links are managed. For example, a weather satellite has a mission payload center that takes the raw data from all of the sensors on the satellite, processes it, and develops a weather map. The map is then sent to weather forecasters around the world.	
d) **Personnel**, called operators, run the facilities and conduct operations. Should a satellite problem occur, operators take action to prevent or minimize any compromise to a satellite's mission.	
c) **Space Segment** The space segment consists of mission satellites and relay satellites.	
1) **Mission satellites** collect data.	
2) **Relay satellites** perform relaying functions. When a satellite is out of visibility range of a ground station, relay satellites link the gap between the mission satellite and the ground station. Essentially, relay satellites provide for a continuous link between the satellite and the ground station in order to conduct operations	

3) Each satellite is comprised of **subsystems.** Subsystems are categorized as either mission payload or vehicle systems. Mission payload subsystems contain all the equipment necessary to conduct actual mission data collection. For example, if a satellite's mission is weather observation, the temperature, humidity and infrared sensor systems are mission subsystems. The remaining subsystems support the vehicle system. These include power, attitude, thermal control and structural subsystems.	
d**) Data Links Segment** Data links are the "pipelines" through which data is transmitted between the space segment and the ground segment. Satellites generally have three types of data links: 1) **Uplink -** Data transmitted from a ground station to a satellite.	
2) **Downlink -** Data transmitted from a satellite to a ground station.	
3) **Crosslink -** Data transmitted between satellites	
2) **Global Positioning System Space System Elements** The Global Positioning System (GPS) is a great example to use to describe the segments of a real world space systems architecture. As you recall from lesson plan one, the GPS mission is to provide accurate, timely position data in any weather to both military and commercial users. GPS is owned and operated by the military. The following indicate how each space system segment supports the GPS mission.	**PP SLIDE 4**
a) The GPS ground segment consists of four elements: a master control station (MCS), monitor stations, ground antennas and personnel.	
1) The **master control station** is located at Schreiver Air Force Base, Falcon, Colorado. The personnel in the master control station control the navigation payload subsystem. Specifically, the MCS generates precise position and time commands to be transmitted to the GPS satellite, allowing the GPS satellite to provide that precise information to GPS users.	

2) Five **monitor stations** are located throughout the world are at Diego Garcia, Kwajalein Atoll, Ascension, Falcon and Hawaii. Each monitor station is responsible for collecting the GPS signal in order to monitor how well the precise information was transmitted from the MCS.	
3) **Ground antennas** are located around the world and support two distinct networks. Four ground antennas, located at Diego Garcia (an island in the Indian Ocean), Kwajaleen Atoll (an island in the Pacific ocean), Cape Canaveral (off the coast of Florida) and Ascension Island (an island in the Atlantic Ocean), are dedicated to support the navigation payload. The remaining antennas are dedicated to support the vehicle subsystems and are a part of the Air Forces worldwide satellite control network (AFSCN).	
4) **Personnel** located at Schreiver Air Force Base are responsible for the launch, early orbit and day-to-day operations of the GPS system. Personnel use computers to generate satellite commands to ensure the satellite is at peak performance.	
5) The datalink segment connects the GPS satellite to both the mission control station and the monitor stations. For example, timing and signal information is uplinked to the payload system. The payload system downlinks a timing signal to a user's receiver unit. A receiver unit needs four satellite downlinks in order to derive an accurate position.	
b) **Operations.** The GPS ground element conducts GPS operations. The MCS's ground antenna transmits (or uplinks) a precise timing signal to the GPS satellite antenna. This information updates the GPS satellite payload. The payload signal is then retransmitted to the ground via a downlink, where anyone with a GPS receiver can pick up the satellite's signal. The receiver, using four different signals from four different GPS satellites, determines an accurate position by a process called triangulation. The GPS receiver converts the triangulated signal into a readable format to describe the user's exact location.	
3) **Access.** Access is a crucial element for conducting satellite operations. Access is the time when a satellite (space segment) will be in view of a ground station (ground segment) in order for personnel to communicate with the satellite using the data link segment.	**PP SLIDE 5**

Access depends on several factors: the satellite's field of view, the location of the ground station/observer and the satellites orbital position.	
a) **FOV**. FOV is how much of the total earth a satellite's sensor can see at any particular point in its orbit. Since the ground antenna talks to the satellite's antenna, the field of view of the ground antenna must also be considered. Satellite orbit type is another crucial factor to determining access. The orbit size determines the number of times per day the satellite will pass over a ground station. For example, a geosynchronous satellite will be in the same position relative to an observer all the time. Provided the ground station is within the GEO satellite's field of view, the ground station only needs to point its ground antenna in the direction of the satellite to communicate with it. However, if the satellite is in a LEO or HEO, the satellite will pass over a ground position at varying times during the day and only for a limited duration of time. To calculate when and where a satellite passes over a ground position requires complex calculations. These calculations describe a satellite's positions as a function of time, azimuth and elevation. STK, as an analytical tool can demonstrate the complexities.	
b) Circle Analogy. A good way to understand access is to think about the following analogy. Visualize two circles. One circle represents the satellite's field of view, while the second is the ground antenna's field of view. Any time these two circles intersect, the operator has the opportunity to communicate with the satellite. Space Shuttle communications is a classic example of multiple and limited access times between NASA Houston and the shuttle crew.	
4) Now let's look at some STK scenarios to help us demonstrate what we have just learned. (To next page)	**PP SLIDE 6**

B. **PART II - STK SCENARIOS**

This portion of the lesson plan illustrates the space system concepts you have learned about in Part 1. To do this, you will run a self-guided scenario using STK VO software. The scenario, broken down into two parts, will help you visualize the space system described earlier. As you recall, the major concepts introduced in Part 1 were space system elements and access determination.

REFER TO CHAPTER FOUR, PART II - FOR STK SCENARIOS ONE AT ATTACHMENT

Recommend handing out the attachments to the students and let them accomplish the scenarios at their own pace.

C. **PART III - STUDENT PROBLEM**

This portion of the lesson plan provides an opportunity for you to apply the concepts you have learned in Part I and Part II by solving a problem.

<u>PROBLEM</u>

The International Space Station, ALPHA, is a low earth orbiting satellite at approximately 240 NM above the earth. Relative to other satellites, it can be viewed by a ground observer at dusk. Using STK, calculate the access time when ALPHA could be viewed over Montgomery, Alabama ground position for today's date.

Then, following similar instructions, see if you can compute the access time for YOUR location.

How would you do this???

Proposed Solution

REFER TO CHAPTER FOUR, PART III - FOR STK PROPOSE SOLUTION, AT ATTACHMENT

STK performs these complex access calculations. To generate a report, load **scenario\lesson4\Alpha\Alpha_problem.sc** and proceed with the following steps.

1. Select **STK window and highlight ALPHA_Problem**. Select **PROPERTIES**, **BASIC**, and **TIME** period tab.
2. Enter today's date under START time.
3. Enter the date five days from now under stop time.
4. Select **APPLY** and **OK**.
5. Select **the VO map** and expand the window.
6. Select **RESET** if ALPHA's orbit is not visible.
7. Expand the globe so that the north and south poles touch the top and bottom of the screen respectively. Orient the globe so that the words "Montgomery AL" and ALPHA's orbit are in view.
8. Observe ALPHA's orbit.
9. Select **START.**
10. Select **PAUSE**.
11. Select **the STK window**.
12. Highlight **Montgomery_AL.**
13. From the pull down window select **TOOLS** then **ACCESS.**
14. **The Access for Facility-Montgomery_AL window** will appear.
15. Highlight the associated object (MIR) and select **COMPUTE.**
16. A ***** will appear when computations are complete.

Continued on next page.

17. Select **ACCESS** under reports.

- The report indicates when ALPHA will be overhead in Montgomery for the days specified. Select a time when it is dusk or at night. Remember to subtract 6 hours (standard central time) to convert UTCG to local time.

18. Cancel out of report and select **AER.**

- Select the time used in step 17. Your display now indicates what direction you should look in to find the MIR.

Now accomplish the actions to find out the access for YOUR city.
Follow the instructions in the scenario.

D. **PART IV - SUMMARY**

In this lesson, you have reviewed the concepts that enable satellite operations to be conducted. First, a space system, consisting of a ground element, a space element and a data link element, provides for the connectivity necessary to conduct operations. Second, satellite to ground access must be calculated to determine when operations can be conducted. Access is based on the satellite's field of view, the location of the ground station, the satellites position in orbit and the ground antenna's field of view. Access tells us when and where to look for a satellite by specifying the time, the azimuth, and the elevation for each satellite pass over a specific area. Both pieces of the equation must be in place in order for a ground operator to conduct satellite operations.

TRANSITION:

Are there any questions??

Break!! You have just completed Scenario Four.